

The politics and economics of Europe's comparative advantage in violence

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By the eighteenth century, Europeans dominated the military technology of gunpowder weapons. Their dominance was surprising, because the technology had originated in China and had been used with expertise in East and South Asia and the Ottoman Empire. Historians have often invoked competition to account for the Europeans' military prowess, but competition cannot explain why they forged ahead in developing this technology. The answer lies in the peculiar form that military competition took in western Europe: it was a tournament that induced European rulers to invest heavily in improving the technology of gunpowder weapons. Political incentives and military conditions kept such a tournament from developing in China, Japan, India, and the Ottoman Empire, and as a result rulers had much less reason to push the gunpowder technology.

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In recent years, historians, economists, and other social scientists have energetically debated when Western Europe first forged ahead of other parts of the world—in particular, advanced parts of Asia—in the race toward economic development. Was it only after 1800, with the Industrial Revolution well underway, that Western European per-capita incomes, labor productivity, or technology diverged? Or was it earlier, before the Industrial Revolution? And what was the cause of the divergence? Was it beneficial institutions, which stimulated investment and the accumulation of human and physical capital? The evolution of cultural practices that encouraged hard work and education? The Scientific Revolution and the Enlightenment, which spread useful knowledge and political reform? Or was it simply an accident that the Industrial Revolution started in Western Europe?¹

In this debate, one area in which Western Europe possessed an undeniable comparative advantage well before 1800 seems to have been overlooked—namely, violence. The states of Western Europe were simply better at making and using artillery, firearms, fortifications, and armed ships than other advanced parts of the world and they had this advantage long before 1800. By 1800, Europeans had conquered some 35 percent of the globe, and they controlled lucrative trade routes as far away as Asia.² Some of the land they subjugated had come into their hands because of new diseases that they introduced into vulnerable populations, and in these instances—in the Americas in particular—their advantage was not military, but biological.³ But other inhabitants of densely populated parts of Eurasia would have had the same biological edge. Why was it therefore the Western Europeans who took over the Americas, and not the Chinese or the Japanese?

The history of conquest is not the only evidence for Western Europe's military advantage before 1800. States elsewhere—China, Japan, and the Ottoman Empire—certainly possessed firearms or ships equipped with artillery, but by the late seventeenth century, if not before, nearly all of them had fallen behind in using this technology, which we will label the “gunpowder technology.” The case of the Ottoman Empire is illustrative. There the military gap may reach back as far as 1572, when Venetian cannon founders judged that guns captured during the naval battle at Lepanto were simply not worth reusing. The Ottoman cannons had to be melted down—and new metal had to be added to the mixture—because “the material is of such poor quality.”⁴ At a time when the high cost of manufactured goods meant everything was salvaged—even clothing from fallen comrades—that amounts to strong evidence from revealed preference about how much better Western European weapons had become. The history of trade and the migration of military experts points in the same direction. Although the Ottomans had a “robust ordnance industry” and could threaten Vienna as late as 1683, they did import weapons from western Europe and often relied on the expertise of European military specialists⁵.

The Ottoman Empire was hardly exceptional. From the Middle East to East Asia, experts from Western Europe were hired throughout Asia to provide needed help with gun making, tactics, and military organization. They ranged from renegade European gun founders in the sixteenth century to Napoleonic officers the early 1800s. In seventeenth-century China, even Jesuit missionaries were pressed into service to help the Chinese Emperor make better cannons. The evidence for Western Europe's military prowess is so strong that it has even convinced some of the historians who argue against

any divergence between Western Europe and advanced areas of China before 1800.

Although they would argue that Western Europe was not wealthier or more developed than rich areas of China, they would acknowledge that its military technology was more advanced.⁶

The evidence is thus fairly clear, but it is nonetheless surprising that western Europe had come to dominate this technology of gunpowder weapons so early. Firearms and gunpowder, after all, had originated in China and spread throughout Eurasia. States outside Western Europe possessed the revolutionary weapons and did become, at least for a while, proficient at manufacturing or exploiting the new military technology. The Ottomans, for instance, long made high quality artillery—perhaps as late as the 1700s.⁷ The Japanese discovered—some twenty years earlier than Western Europeans—the key tactical innovation (volley fire) that allowed infantry soldiers with slow loading muskets to maintain a nearly continuous round of fire.⁸ Yet by the late seventeenth century, if not before, Chinese, Japanese, and Ottoman military technology and tactics all lagged behind what one found in western Europe.⁹

Why did these other powerful states fall behind? A number of gifted military historians have worked on the topic, but most simply describe the Europeans' proficiency, without unearthing its underlying causes. The closest they come to a deeper explanation is the claim that military competition in Europe gave the Europeans an edge. The argument, which dates back to Gibbon, has been formulated most cogently by Paul Kennedy, who points to Europe's competitive markets and persistent military rivalries. While military rivalry created an arms race, competitive markets encouraged military innovation and kept one country from establishing an empire.¹⁰ That would explain why

the military sector in early modern Europe turns out to have experienced rapid and sustained productivity growth—an outcome unknown in other parts of the economy.¹¹

Competition, however, is not the final answer. Although it is a first step in the right direction, there is more that needs to be explained. First of all, competitive markets do not always stimulate innovation. The clearest example comes from agriculture in early modern Europe, which had highly competitive markets but witnessed virtually no productivity growth.¹² What kept early modern European farmers from reaping the productivity gains of soldiers and sailors?

Nor do ongoing military rivalries always stimulate innovation. They in fact failed to do so in eighteenth-century south and southeast Asia, and in nineteenth-century Latin America too. The case of India, as we shall see, is particularly illuminating, for like Europe it had markets and incessant warfare, and the combatants were quick to adopt the latest weapons and tactics. The innovations, however, by and large originated elsewhere.

The answer to this conundrum lies with the peculiar form of competition that European rulers were engaged in up until 1815. It was not the garden variety economic competition that prevails among small entrepreneurs who maximize profits and at least in theory pay no attention to other firms. Rather, it was political competition in what economists would call a tournament. Competitors in a tournament—in contrast to the idealized small entrepreneurs—must pay attention to one another, because their relative standing determines who wins a single prize. And doing worse does not simply reduce their profits, as with entrepreneurs; rather, it means they win nothing at all.

A tournament of this sort had long engaged the monarchs of Europe, and tournaments among rulers existed in other parts of the world as well. Under the right

conditions, they spurred rulers to improve military technology in the broadest sense of the word, even at the expense of the rest of the economy. In early modern Europe, the conditions were conducive to advances in military productivity. Elsewhere, however, they were not. Understanding why requires a look at the political, military, and fiscal incentives rulers faced, both in Europe and in other parts of Eurasia. It also requires a glance at the costs and benefits of other military technologies.

1. The tournament in Europe and its consequences

The states that coalesced in Europe in the waning days of the Middle Ages by and large had a single purpose, at least if we judge by what they levied taxes and borrowed money for. That purpose was clearly warfare. True, funds were spent on justice and palaces, and there was a pittance for transportation and famine relief. But particularly in the major powers, some 40 to 80 percent of the budget went directly to the military, to defray the costs of armies and navies that fought almost without interruption (see Table 1 for the frequency of battles). The fraction of the budget devoted to war climbed even higher—to 95 percent in France during the 30 Years War—if we add sums spent subsidizing allies or paying of the debts of past wars.¹³

In early modern Europe, decisions about war typically lay in the hands of a ruler such as a king or a prince. He would of course be advised by councilors, and an influential minister (a Richelieu or Olivares) might sometimes be dictating most of the decisions. But the assumption that a king or prince made the decisions about war is not far from historical reality. Even in eighteenth-century Britain, where Parliament and the

cabinet decided whether to commence hostilities, the choices about the conduct of the war once it had begun were up to the king.¹⁴

What then made European kings take up arms? That question has to be answered if we are to understand what the tournament was. In Europe's major powers, the rulers often won control of warfare in the process of assembling their states in the late Middle Ages or the sixteenth century. They might have constructed their states by defeating domestic and foreign rivals, but typically they offered even conquered provinces protection from foreign enemies, in return for tax revenue. In modern terms, one would say that they provided the public good of defense in return for taxes.

That public good was precious, as anyone who suffered through the horrors of the 100 Years War in France or the 30 Years War in central Europe could testify. But the rulers of early modern Europe likely provided far more defense than their average subject would have wanted. The reasons were not hard to understand. The kings and princes had been raised to fight one another, with toy soldiers, pikes, and firearms as children and actual training in their youth. Advisers like Machiavelli might tell them that princes "ought to have no object, thought, or profession but war." Their own fathers would teach them that war was a path to glory, a means to "distinguish [kings] . . . and to fulfill the great expectations ...inspired in the public," in the words of Louis XIV's instructions for his son. They took the lesson to heart and once enthroned often surrounded themselves with images exalting their role as military leaders or glorifying the martial exploits of their reigns, as Louis XIV himself did at Versailles. And they pursued war with gusto, at least if they ruled over a major power. Fighting had gone beyond the needs of defense and become, in the words of Galileo, a "royal sport."¹⁵

Glory did recede as a motive for war in the eighteenth century, when the major powers might fight simply to preserve their reputation, to gain commercial advantage, or to snatch territory from weaker neighbors. But war was still “what rulers did,” the normal target for their ambitions. It continued to appeal to them, just as it long had attracted much of the European aristocracy.¹⁶

For the major monarchs of early modern Europe, victory was thus a source of glory or a way to enhance their reputation. They could gain smaller amounts of prestige by fighting, or even by raising a large army. Grabbing territory from small neighbors would add to their standing and augment their resources. And whatever the outcome was, they faced little risk to their thrones, at least in the larger states. Smaller principalities might be swallowed up if defeated, but for western Europe’s bigger powers, loss in battle in anything but a civil war never toppled a monarch from his throne, at least in the years 1500-1799 (Table 2).¹⁷ Nor did warfare threaten Europe’s kings and princes with personal financial ruin, for the funds to pay for war by and large came from tax revenues, not from the rulers’ own possessions. Although they might worry about tax revolts, the negotiations that went into the construction of the larger European states insulated powerful elites from many of the tax increases. Without backing from the elites, the revolts were less of a threat.¹⁸

Europe’s major monarchs thus had every reason to fight and even stronger reasons to outdo their neighbors and win victories. They would have an incentive to vie with one another for a prize that would go to the winner and they would really exert themselves, because victory would depend on beating or outlasting their enemies. Of course not all rulers would participate. Some countries would be too small, and others

(the Netherlands in the eighteenth century, for example), though big enough to fight, would bow out, or at least not enter a particular war.

Such a contest is an example of the economists' tournament. Potential contestants can choose whether or not to join in, and the reward that motivates them depends on their relative performance. To win the prize, they exert effort, which may be harder or more costly for some potential entrants than others. If the reward is large, the effort elicited can be huge, particularly if the number of contestants who enter is not too large.

This sort of tournament is what drives top notch athletes, such as a talented baseball player, to extreme measures in the quest for success. The prize the baseball player seeks is a professional career, and victory depends on whether he is better—even by only a slight amount—than other players. He is therefore likely to go to extremes—such as taking drugs that may harm him later in life—just to get that slight margin of victory. A tournament, it has been argued, is also what justifies the pay of corporate CEOs. Their huge compensation packages are the prize that motivates executives below them to push themselves in the hope of someday becoming CEO's themselves. Tournaments are also used to promote research and improve technology. The defense department has in fact run tournaments to choose whether Lockheed or Northrop would develop an improved jet fighter, and it has sponsored a recent one to support research on robotic vehicles.¹⁹

Here skeptics may complain that the notion of a tournament really adds little and that it seems little more than a complex label stuck on the older and altogether adequate idea of competition. Yet a closer look at the features of tournaments should help put that

objection to rest, particularly if we look more closely at the tournament in early modern Europe and compare it with military rivalries elsewhere in the world.

To begin with, there is one feature of tournaments that clearly distinguishes them from garden variety economic competition, as we can see by varying the number of entrants who compete. In a tournament, if only one competitor enters—one prince, for instance, in early modern Europe—he will exert no effort. He does not have to, because his prize is guaranteed. In a market, by contrast, a single entrant, such as the lone firm making a product, may well exert itself, because it can sell goods at a monopoly price. The monopoly rights may in fact give the firm a powerful incentive to do research that will make its monopoly even more valuable. A single competitor in a tournament would never behave that way.

Other differences emerge as the number of competitors grows. In a market, competition increases with the number of entrants, but that need not be so in a tournament. Indeed, under certain conditions, the total effort expended may even fall as the number of entrants rises above two, for the odds of winning fall, which reduces the expected value of any prize. Someone who designs a tournament can in fact usually achieve any desired level of effort at lowest cost in term of the prize that has to be offered simply by limiting entry to two competitors.²⁰

That is how many competitors the tournament in early modern Europe often had, particularly if we take into account the alliances between countries. The Hapsburgs battled the kings of France in the sixteenth and seventeenth centuries, and the English fought French in the eighteenth. Other sizeable powers—the Swedes and the Dutch—dropped out, while smaller countries simply did not participate, except perhaps as allies.

The number of rivals who actually entered the tournament was thus small enough to keep them from getting discouraged, and inducing them to expend effort did not require an outsized prize, at least if its value is measured relative to the costs of joining in, which would include the political and financial expenses involved in setting up armies, navies, and fiscal systems.

What did all this effort go for? It went to fund larger armies and navies and to improve tactics, logistics, and military technology. Gunpowder weapons required centralized revenue and expenditure, particularly as armies and navies swelled and the technology improved. In an era before nationalism motivated troops, armies had to be centralized, for if soldiers (many of whom were mercenaries) were scattered across a country, desertions would soar. The cost of shipping supplies to the infantry also encouraged the centralization of armies, and it had a similar effect on navies. Countries that could organize more effective provisioning could prevent mutinies and desertions and retain the loyalty of veteran troops, who often provided the margin of victory.²¹ As for navies, they needed suitable ports, meaning ones which could easily be defended and which, at least by the eighteenth century, would be deep enough for ships of the line. The scarcity of such harbors also favored centralization.²² Fortifications had the same effect. It was extraordinarily expensive to build them large enough to house a defensive battery of cannons and strong enough to stand up under an siege, and their design required the expertise of skilled military architects. The cost put them out of reach for small principalities and limited the number that could be constructed. Even in large kingdoms the money devoted to fortifications had to be allocated carefully, so as to protect frontiers, key passes, and vulnerable cities.²³

The clearest mark of all this effort was huge great increase in the tax revenues that central governments collected, at least among the major powers. For France and England, where fiscal records begin early, the per capita tax burden (measured in grams of silver) rose over 6-fold between the 1540s and the 1780s (Table 3). Picking other decades or measuring per-capita taxes in grain or days of a workman's labor would not change the results appreciably. By the eighteenth century, France may have been spending 5 to 10 percent of its GDP on military, and Great Britain even more—perhaps as much as 28 percent.²⁴ For countries that were still poor by modern standards, these figures are quite high. For comparison, at the end of the Cold War, the United States was spending 5 percent of its GDP on the military, and the USSR perhaps 10 percent.²⁵

Here one might object that raising taxes would take no effort at all, at least in absolute monarchies like France and Spain. But even under absolutism taxes were limited by the concessions made to elites when kingdoms were assembled. The kings of France and Spain could not simply raise taxes at will without provoking elite resistance, particularly in provinces that had joined the kingdom late. The monarchs had to negotiate, offer additional privileges and liberties, or simply go without added revenue. Outside of Britain, which was far ahead of the rest western Europe, it would take the even greater efforts of centralization during the Napoleonic Wars (and the creation of national representative institutions in the nineteenth century) before the constraints on tax revenues were finally relaxed.²⁶

Rulers also strived to improve military technology, in the broad sense of the term: not just the design and manufacture of ships and weapons, but tactics, logistics, and training too. In the sixteenth century, King Philip II of Spain hired away talented military

architects from Italy and gunners from Flanders, France, and Germany. He also rewarded military inventors and established academies to train military engineers. Two centuries later, the French were subsidizing the British iron master William Wilkinson in an effort to acquire British technology for manufacturing cannons.²⁷

These efforts helped spread the best military technology. So did widespread espionage and states' efforts to copy what was successful.²⁸ Yet the technology would have spread even if states had not sought to imitate their rivals and hire away talent, via Europe's long established market for military goods and skills. Officers and professional soldiers had long been able to hire themselves out and even switch sides, with Wilkinson being far from the first entrepreneur who helped spread new techniques of making weapons.²⁹ Efforts to interfere with the market usually failed: the Habsburg Emperor Charles V, for example, could not stop gunsmiths in Nürnberg from selling handguns to his enemies the French. Assistance to allies was another major channel for the diffusion of technology. Sweden's King Gustavus Adolphus, for instance, trained with the Dutch and then improved upon the infantry tactics (such as volley fire) that they had pioneered.³⁰

Better technology did not spread overnight—otherwise no ruler would have had an incentive to innovate—but it did eventually diffuse among the military powers and keep any one of them from gaining a monopoly on military strength. The effect was to make the European tournament work almost like an idealized prize system that put winning ideas into the public domain. Rulers of major powers had every reason to improve their militaries, because wanted the glory, renown, or added territory that came with victory, but they would be less likely to pile triumph upon triumph and come to

dominate the entire continent or even put an end to the tournament itself. Competitors would thus begin each new tournament with roughly the same improved technology and the same impetus to push it even further.³¹

We can actually measure the rate at which military technology was improving, in the same way that we can gauge the productivity of modern workers and industries. The yardsticks used are perhaps crude and fail to capture advances in tactics or provisioning that were an integral part of the gunpowder technology. They also have trouble with naval warfare, where western Europe's lead was perhaps greatest. The reason, beyond the scarcity of quantitative data for early navies, is simply that warships had variety of different goals, which varied over time. Firepower dominated the eighteenth century, but speed, range, and an ability to fight in inclement weather were also important, particularly in wars of economic attrition that were focus of earlier warfare at sea.³²

Yet despite all these difficulties, the evidence that military productivity was advancing in early modern Europe is clear. Captains in the British navy, for example, learned how to become much more effective fighters, which drastically cut their fatality rate. If one holds constant the intensity and amount of fighting the captains were exposed to, their odds of dying in typical five year period fell from 16 percent in 1670-90 to one in a thousand in 1790-1810.³³ On land, the effective firing rate per French infantryman jumped by a factor of 6 or more between 1600 and 1750, as bayonets made it possible to replace pike men and matchlocks were supplanted by flintlocks with ramrods and paper cartridges (Table 4). The higher firing rate translated into labor productivity growth of 1.3 to 1.7 percent per year, which rivals what developed countries experienced in the late twentieth century and far exceeds what one would expect for preindustrial economies.

Yet another sign of rapid productivity growth was falling price of weapons, which dropped faster than the cost of factors of production or of other manufactured goods (Figure 1).³⁴ Like modern computer manufacturers, the gunsmiths of late medieval and early modern Europe were growing more effective at making weapons, and as in modern industries the productivity growth was particularly rapid when new weapons were first introduced. When the first handguns appeared on the scene circa 1400 (they were little more than tiny, hand held cannons that could be fired from atop a city's walls), the metal founders who cast them reduce the price drastically.³⁵ They did so by cutting the amount of copper they used, so that the weight of the cannons dropped (Figure 2). That may seem obvious to us, but in an era when cannons regularly exploded (Figure 3), it marked real progress.

Rising productivity is what would be expected from a tournament, if the prize was high, if the number of contestants was small—but greater than one—and if the technology was one that made innovation economically and technologically feasible. Those were precisely the conditions prevailing among the major powers in early modern Europe. The gunpowder technology did in fact allow for many improvements, not just to ships and weapons, but to tactics, organization, and provisioning. The growth of per-capita taxation would also be expected under these conditions, because it would be evidence of the enormous effort the tournament elicited. By contrast, productivity growth is not what we would expect from competitive markets in early modern Europe. The continent had many such markets, but in large ones, such as the military sector, productivity growth was non existent. The evidence thus seems consistent with a story of

a tournament with conditions favorable to military innovation. But what about the rest of the world? Does the same story work elsewhere?

2. Comparison with the Rest of the World

If the story about the tournament is correct, then it should explain why Europe gained a comparative advantage in the technology of artillery, firearms, fortifications, and armed ships. In particular, it should help explain why Japan, China, and the Ottoman Empire eventually fell behind in the use of the gunpowder technology. Presumably, either they did not have a tournament, or if they did, the conditions were not the same as in Europe.

The case of Japan is perhaps clearest. After firearms were introduced there in 1543, battling warlords and their opponents swiftly became experts in their manufacture and use. They deployed them in virtually constant warfare that wracked the fragmented country, and they innovated, just as in Europe. Not only were the Japanese the first to use volley fire, but they too devised fortifications that could resist artillery siege. And as in Europe, the ability to mobilize resources and provision armies effectively proved critical with this technology. The military innovations ground to a halt, though, after country was unified in the late sixteenth century.³⁶

It all sounds reminiscent of the tournament in Europe. As long as the civil war continued, the warlords and the other combatants would have powerful reasons to improve the technology, so long as there were not too many rivals involved. But once the

country was unified, the tournament would be left with only one contestant, and the incentive to advance the technology would disappear.

What about China and the Ottoman Empire? Before we consider them, it is worth noting that gunpowder was not the only military technology and that it would actually be ineffective against certain enemies. China, for instance, faced attacks by nomads on horseback, and against them, artillery and handguns were of little use. The nomads were too mobile for artillery and had no cities to besiege. Sending the infantry chasing after them would demand too many provisions, since the nomads could simply ride off into the steppes and live off the land. The best thing to do would be to fight them with cavalry armed with bows and swords, the same weapons the nomads utilized. Muskets gave no advantage, because they could not easily be fired from horseback, and while pistols could, their range was limited. Centralized provisioning and tax collection, which was crucial with gunpowder technology, might also prove ineffective. It might simply be better to have soldiers settle near the frontier regions where the nomads were most likely to attack. They could make some of their own equipment and grow some of their own food. Such a strategy of partial military decentralization was in fact pursued early in the Ming dynasty.³⁷

The other major threat to Chinese emperors was rebellion, but rebels, at least if they were peasants, would be less likely to use firearms, because the private production and ownership of guns was limited in China.³⁸ In sum then, the military dangers facing China made the gunpowder technology less attractive, although its appeal increased at the end of the Ming dynasty, when something like an arms race began to develop in east

Asia.³⁹ And the technology that was preferable, particularly against the nomads—bows and swords—may have simply ruled out much innovation.

Efforts to advance military technology of any sort may have also been hampered by a belief that the emperors of China should focus on peace and use force as a “last resort.” Such a political norm, which may have been particularly strong under the late Ming, would have lowered the value of the prize if China ever were engaged in a tournament and it might have deterred the emperors from chasing conquests.⁴⁰

Europeans who knew China well would likely agree here. One of them—the Jesuit missionary Matteo Ricci, who died in Peking in 1610 after spending 28 years in China—noted that although the China could easily conquer neighboring states neither the emperors nor Chinese officials had any interest in doing so. “Certainly, this is very different from our own countries [in Europe],” he noted, for European kings are “driven by the insatiable desire to extend their dominions.”⁴¹

One other factor may have also worked against military innovation in China, no matter what the technology: the size and durable unity of the empire. For nearly three quarters of the two millennia between 221 BC and the nineteenth century, the Chinese Empire was intact; western Europe, by contrast, spent much more time fragmented into warring states. Indeed, after the fall of the Roman Empire, western Europe knew only two short lived empires (the Carolingian and the Napoleonic), and it thus lived through a millennium and a half of nearly uninterrupted disunity. More often than not China was thus in a situation like Japan after it was unified under the Tokugawa Shogunate: even if the Chinese emperors had wanted to compete in a military tournament, they would be the lone competitors and have no reason to exert any effort. The only exception would be

when the empire happened to be at war or was fragmented into hostile powers. Then public defense might have created incentives for innovation, or China might have been going through something like early modern Europe's tournament, and we would expect to see military innovations, though not necessarily with the gunpowder technology.

There is one final condition that may have kept the Chinese from pushing the gunpowder technology. When this technology finally became appealing in the seventeenth century, it may simply have been more advantageous to acquire it from the Europeans, by asking the Portuguese (or the Jesuits) to provide designs and expertise.⁴² The European rulers, after all, had already been through a tournament. They had paid the costs of entering the tournament and expended a great deal of effort to improve the gunpowder technology. The resulting innovations were now part of the public domain or offered for sale at competitive prices. Why should a Chinese Emperor pay the same entrance fees and duplicate the Europeans' efforts, when it might be cheaper simply to buy the European innovations by hiring European experts?⁴³

Quantitative evidence bears out these claims about China. The Chinese did invent a large number of weapons—more than just gunpowder and firearms—and not surprisingly the discoveries tended to be made when emperors were at war.⁴⁴ But over the years 1500-1799, China was less likely than major European powers to be fighting foreign enemies against whom gunpowder weapons might prove useful. It was less likely to be battling foreign enemies overall, and most of the hostilities involved civil wars or nomads, which left little room for innovation. If these two sorts of strife are set aside, the contrast with major European powers is striking (Table 5). So at the very time when gunpowder technology was advancing, China's rulers had less reason to cultivate the new

weapons, and the Chinese military had much less experience with them. Greater experience could of course translate into learning how to improve the technology, as with British naval captains.

The Chinese emperors also seem to have done less to raise and centralize taxation, as would be expected if the gunpowder technology was not the focus of their efforts. The central government's per capita tax receipts (measured in grams of silver) in fact turn out to have been much lower in China in the years 1520-1630 than in England or France (Figure 4). One could argue that part of difference was due to the relative price of silver in China, where silver was dear relative to gold, but converting to gold would multiply the Chinese figures by a factor of at most 2 relative to Europe, which does not eliminate the enormous difference. True, some of Chinese figures come from the waning days of Ming dynasty, but the much higher numbers in Europe are a mark of the enormous effort that the tournament there elicited. Conditions in China were different, and the Ming Emperors therefore had no reason to squeeze taxpayers so hard, even when the Empire was at war. Fighting the nomads did not hinge on centralizing the provisioning system, and raising taxes always risked rebellion.

A similar argument might fit the Ottoman Empire, which had to confront both nomads and enemies who employed the gunpowder technology. The Ottomans could therefore not devote all their resources to gunpowder, as the Europeans could, and it is perhaps not a surprise that the central government's tax receipts failed to keep up collections in Europe.⁴⁵ Nor is it startling that their conquests tended to shift toward the east. To the west, they faced European powers whose militaries could specialize in the gunpowder technology and whose armies and navies were growing stronger, thanks to a

tournament operating under the right conditions. Eventually the Ottomans began to import weapons and expertise from the Europeans.⁴⁶ For them too, the conditions were not as auspicious as in Europe, and in particular, it was not worth their while to pay the costs of innovation when they too, like the Chinese, could import it when needed from the West.

The most telling comparison, however, is between Europe and India, which should have been fertile ground for advances in gunpowder technology, if the traditional argument about competition were correct. India witnessed virtually constant warfare and had highly developed markets for military goods and services.⁴⁷ The claims about competition would predict that Indians would therefore push the gunpowder technology further, yet while they readily adopted new weapons and tactics, they did not break new ground in their use. The innovations, by and large, came from the West with renegade experts and officers and imports of weapons.⁴⁸ That runs counter to what the claims about competition would lead one to expect.

Part of the reason was that India, like the Ottoman Empire, had one foot in the nomadic zone. For a long time, then, the gunpowder technology was little use, and armies were predominantly (though not exclusively) cavalry, particularly under the Mughal Empire. But in eighteenth century, as the Mughal Empire disintegrated, the gunpowder technology became advantageous. Yet even at that point the Indians failed to innovate. Their highly developed military markets meant that they quickly embraced the latest that the gunpowder technology had to offer, but they did not push it further on their own.⁴⁹

The model of the tournament can explain why. There was a military tournament in India, with political competition, but the conditions differed greatly from those in Europe and in fact worked against improvements to the gunpowder technology. To begin with, there were simply too many competitors in India—too many entrants in the tournament. One reason was that alliances were weak and allies often defected, leaving the Indian tournament with far more than the two rivals common in Europe.⁵⁰ The contestants thus had less of an incentive to exert themselves and break new ground. In addition, as with China, there was no point putting any effort into innovation if the Europeans had already made the advances. Why pay the entry costs and duplicate their work? It would be better simply to copy their technology and hire their experts.

Two other features of the Indian tournament—both absent in Europe—also hampered efforts to enhance the gunpowder technology. It was common in India for strife to break out within families over succession to a throne or rights to rule. Conflict of this sort, which had grown rare in Europe after the late Middle Ages, reduced the value of the prize in the Indian tournament, by raising the odds that a prince or other ruler would be unable to enjoy fruits of victory. As a result, Indian rulers would exert less effort to improve weapons and tactics or centralize provisioning and taxation.

The political and economic costs of centralizing taxation and army funding may have also been higher in India. It seems to have been easier for Indian military leaders and other members of the elite to defect and join the enemy. Behavior of this sort was less common in Europe, particularly after the early seventeenth century. Indian rulers might therefore have hesitated before raising or centralizing taxes out of fear that elites would jump ship.⁵¹ In addition, grain markets in eighteenth and early nineteenth-century

India were more fragmented than in Europe, which would make centralized provisioning and tax collection more difficult.⁵² In a tournament, all the higher political and economic costs would in turn mean less effort overall.⁵³

If we consider the most powerful successor states to the Mughal Empire, most of them did fail to develop centralized tax and supply systems. That is a telltale sign that the conditions in the Indian tournament were different, because advancing the gunpowder technology depended on centralizing the fisc and provisioning. In this situation, the East India Company thus had an enormous advantage in India, even though it was only a private enterprise, because it could easily use its own financial system, which was already in place, to centralize the funding of war. That advantage allowed it to conquer much of India, simply by hiring away the best officers and their troops.⁵⁴

3. Conclusion

The idea of the tournament yields a deeper understanding of why Europeans pushed the gunpowder technology so far and why therefore they were the ones to conquer the world. The rulers of western Europe's major powers were competing in a tournament, under conditions that drove them to improve the artillery, firearms, fortifications, and armed ships that they deployed in their wars. Since the gunpowder technology required it, they raised taxes and strove to centralize provisioning and the fiscal system. They overspent on the military and provided more defense than their subjects likely desired. But they had little reason not to. Victory in the tournament won them glory, enhanced reputations, and resources from territory snatched away from

smaller neighbors. Losses never cost them their throne, at least for the major powers and as long as they faced no civil war. Finally, they did not bear the full costs of warfare, and neither did elites with political voice, who in any case often aspired to military careers.⁵⁵

The small number of contestants in Europe kept the level of effort high, in contrast to what happened in India's tournament. The economic and political costs of centralization were more favorable in Europe, while the value of the tournament prize was not diminished by frequent strife over succession. And in Europe, the market for weapons and military skills helped prevent one country from getting too far ahead, although there was an important element of historical contingency involved. Had one power crushed the others—the Habsburgs in the sixteenth century, or Napoleon at the height of his power—the tournament in Europe would have halted, as it did in early modern Japan. But that never happened in Europe. It never enjoyed the political unity that would have cut the incentives for military innovation, as in China or in Japan under the Tokugawa Shogunate.

Other factors were of course involved. Against nomads, the gunpowder technology—and the centralized provisioning and tax collection that went with it—were of little use. It therefore had limited appeal to Ottomans, and even less to the Chinese. But even here the tournament gives us insight. When the technology finally did become attractive, as in eighteenth-century India and perhaps in seventeenth-century China too, it may have simply been cheaper to buy it from the Europeans. Why the pay the cost of entering a tournament that would simply duplicate their efforts, when it would be so much easier to hire their experts and purchase their weapons?

Although this argument may seem persuasive, there are still a number of questions that remain. How do we explain the historical contingencies that brought a tournament to an end in Japan and kept it alive in Europe? What role did relative prices of land and labor play, and how did they affect the political incentives for centralizing taxation and the provision of defense? What accounts for the smaller number of competitors in Europe and ease with which alliances could be formed? Did it derive from rules of succession, or perhaps from marriage practices, since matrimony often sealed alliances in Europe? And did the actual operation of the tournament—with potential competitors having to pay the initial cost of establishing a standing army whether or not they later chose to fight—actually heighten the effort that they would later exert? A more elaborate model of the tournament suggests as much.⁵⁶

Finally, why did the rulers of early modern Europe face incentives that give them every reason to join the tournament and little reason to hold back? Napoleon and the wars of French Revolution did finally overturn these rulers of the game: henceforth losing at war could cost the ruler of a major power his throne (Table 2). Where did these ancient incentives originate and why did they finally change? And what in turn were the political and economic consequences? Far back into the Middle Ages, Europe had overspent on warfare, with disastrous consequences for the economy. With a century of peace after 1815, did the continent reap any economic benefits? Is it any surprise that the continent swiftly followed the British example and industrialized?

Table 1

Frequency of War in Europe

Period	Average Percentage of Time Principal European Powers Were at War
1550-1600	71
1600-1650	66
1650-1700	54
1700-1750	43
1750-1800	29
1800-1850	36
1850-1900	23

Source: (Wright 1942, 1: Tables 29, 45, 46); (Levy 1983) leads to similar results.

Note: The principal European powers are defined as France, Austria, Great Britain, Russia, Prussia, Spain, Netherlands, Sweden, Denmark, Turkey, and Poland.

Table 2

Probability That a Major European Sovereign Was Deposed After Losing a Foreign War

Fraction Deposed Because of Defeat in Each Year of War or in Each Year of War Loss				
Conditional on:				
Period:	Being at War		Losing War	
	1500- 1799	1800- 1919	1500- 1799	1800- 1919
Country				
Austrian Dominions	0.00	0.07	0.00	0.20
France	0.00	0.06	0.00	0.67
Great Britain	0.00	0.00	0.00	0.00
Hohenzollern Dominions	0.00	0.06	0.00	0.50
Spain	0.00	0.10	0.00	0.33

Source: (Langer 1968).

Note: The calculation of the conditional probabilities begins with a count of sovereigns who were deposed after losing a foreign war for the Austrian Dominions, France, Great Britain, the Hohenzollern lands, and Spain. The count includes any assassinations provoked by loss in a foreign war, but it excludes assassination or removal from office during civil wars and internal revolutions, unless the cause was the loss of a foreign war. In particular, the executions of king Charles I of England and Louis XVI of France are not counted, and the same holds for the removal of James II of England and the deposition of Ferdinand II in Bohemia in 1618. The calculations also exclude the simple downfall of ministries. The number of deposed monarchs is then divided by the number of years the country was at war; that yields the probability of deposition after losing a foreign war conditional on being at war. War here is defined as any class of armed conflict significant enough to be included in Langer; no formal declaration of war is necessary. It includes colonial fighting, but it excludes civil wars unless foreign powers are involved. The calculation of the probability of deposition conditional on losing a war is similar; the only difference is the number of deposed monarchs is divided by the number of years in which a war ended with a loss for the country concerned. Sovereigns included all monarchs, whether absolute or constitutional. For republics, the sovereign was the parliament or legislative assemblies; if the legislative assemblies shared sovereignty with a president or other executive, then the sovereign was the executive and the legislative assemblies together.

The Austrian dominions exclude Habsburg territory in Iberian Peninsula, Italy, Low Countries, and Latin America. Bohemia is excluded before Habsburgs assume the crown in 1526, and Hungary is not counted until it was fully integrated into the Habsburg holdings in 1699. For France, the Convention is counted as a sovereign; Napoleon's

abdication in 1814 is counted as a removal after a loss, but not his second abdication after Waterloo. For Great Britain, the calculation concerns England and Ireland alone up until 1603; during the Protectorate, the Lord Protector is counted as sovereign. For Spain, depositions do not include loss of Portugal or of non-Iberian possessions. All the probabilities are ex-post, and they clearly make more sense for monarchies than for republics. The table leaves out countries that were major powers at some point between 1500 and 1800—Sweden and the Netherlands in the seventeenth century, and Russia in the eighteenth.

Table 3
Central Government's Per-Capita Tax Revenue, 1540s-1780s

Country	Per-Capita Taxes (Grams of Silver)	
	England/Great Britain	France
1540s	27.52	9.13
1780s	171.69	68.86
Increase	6.24	7.54

Source: For the French revenue and population figures, see (Hoffman and Norberg 1994, 238-239) and the sources listed there. For England (in the 1540s) and Great Britain (in the 1780s), the revenue figures come from data collected by P. K. O'Brien and P. A. Hunt and posted at the European State Finance Data Base that Richard Bonney has assembled (<http://www.le.ac.uk/hi/bon/ESFDB/dir.html>); and from evidence gathered by Mark Dincecco and made available at the Global Price and Income Group web site at <http://gpih.ucdavis.edu/> and in (Dincecco 2009). The population figures are taken from (Wrigley, Schofield, Lee and Oeppen 1989, Table 7.8) for the 1540s and from Dincecco's data for the 1780s. The Global Price and Income web site is also the source of the silver conversions.

Note: Data are missing for some years in each decade. Silver conversions are based on mint prices.

Table 4

Military Labor Productivity in the French Army:
Rate of Successful Fire per Infantryman, 1600-1750

Approximate Date	Rate of Successful Fire per Handgun (shots/minute)	Handguns per Infantryman	Rate of Successful Fire per Infantryman (shots/minute)	Assumptions
1600 (1620 for handguns per infantryman)	0.25 to 0.50	0.40	0.10-0.20	0.5 to 1 shot per minute with matchlock; 0.50 misfire rate
1700	0.67	1.00	0.67	1 shot per minute with flintlock, 0.33 misfire rate; bayonets have led to replacement of pike men.
1750	1.33	1.00	1.33	2 shots per minute with flintlock, ramrod, and paper cartridge; 0.33 misfire rate.

Source: (Lynn 1997, 457-460, 464-465, 469-472)

Notes: The calculation considers only pike men and infantrymen with firearms; it ignores unarmed soldiers, such as drummers. The implied rate of labor productivity growth over the 150 year period from 1600 to 1750 is between 1.3 and 1.7 percent per year.

Table 5: Frequency of Foreign War in China and Europe, 1500-1799

Country	Fraction of years at war against foreign enemies	
	With wars against nomads	Without wars against nomads
China	0.31	0.08
France	0.52	0.52
England/Great Britain	0.53	0.53
Spain	0.81	0.81
Austrian dominions	0.24	0.24

Source: Micheal Clodfelter, Warfare and Armed Conflicts: A Statistical Reference to Casualty and Other Figures, 1500-2000 (McFarland & Company, 2002); Quincy Wright, A Study of War, 2 vols. (University of Chicago Press, 1942); Zhongguo Junshi Tongshi (Military History of China), vols. 15-17 (Junshi Kexue Press, 1998); Bai Shouyi, editor, vol. 8-10, Zhongguo Tong Shi, vols. 8-10 (Shanghai People's Press, 1999); Peter N. Stearns, The Encyclopedia of World History, page 376-381.

Note: Austrian dominions and Spain as in Table 2. The data for this table were collected by Margaret Chen, a graduate student in economics at UC Davis, for a comparative paper on Europe and China that she and I are doing.

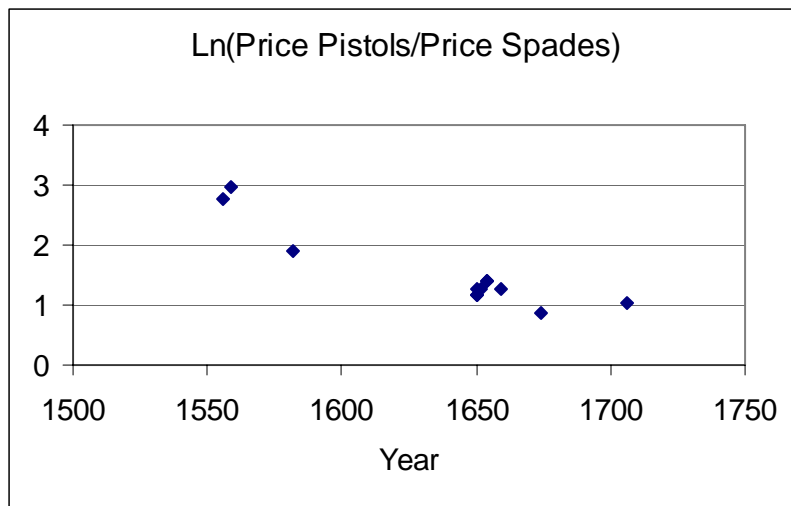


Figure 1: The logarithm of the price of pistols over the price of spades in England.
Source: (Hoffman 2006)

Figure 2: Logarithm of the Price and Weight of Early Handguns in Frankfurt. Source: (Rathgen 1928, 68-74)

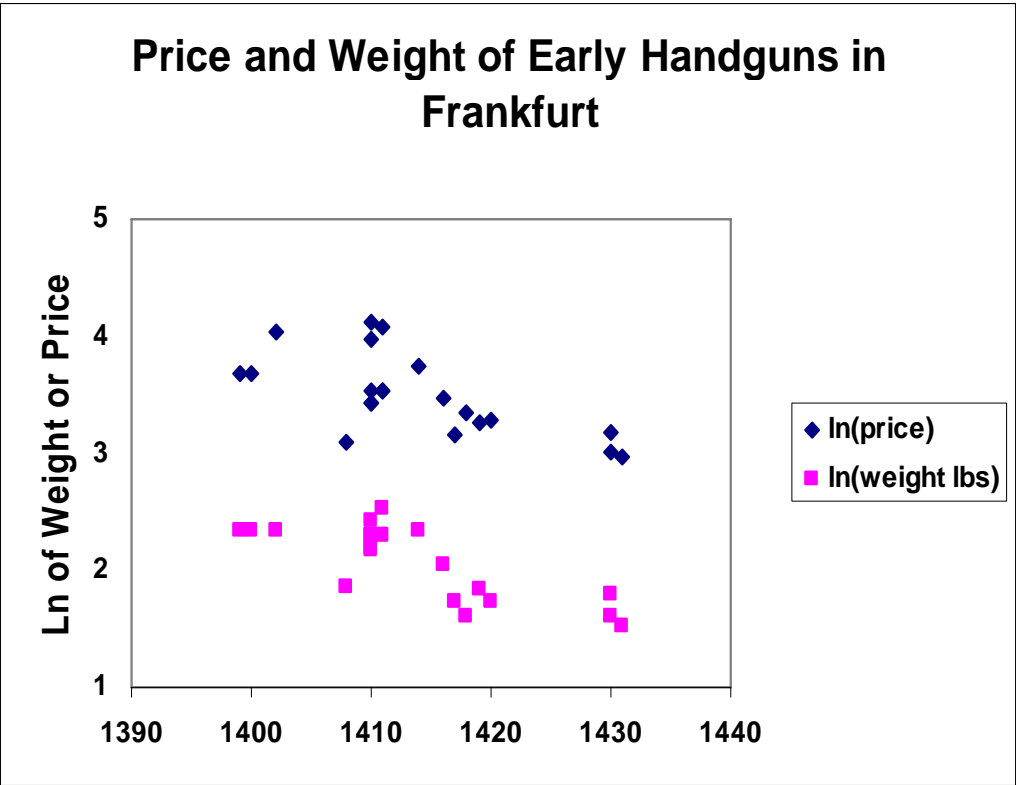
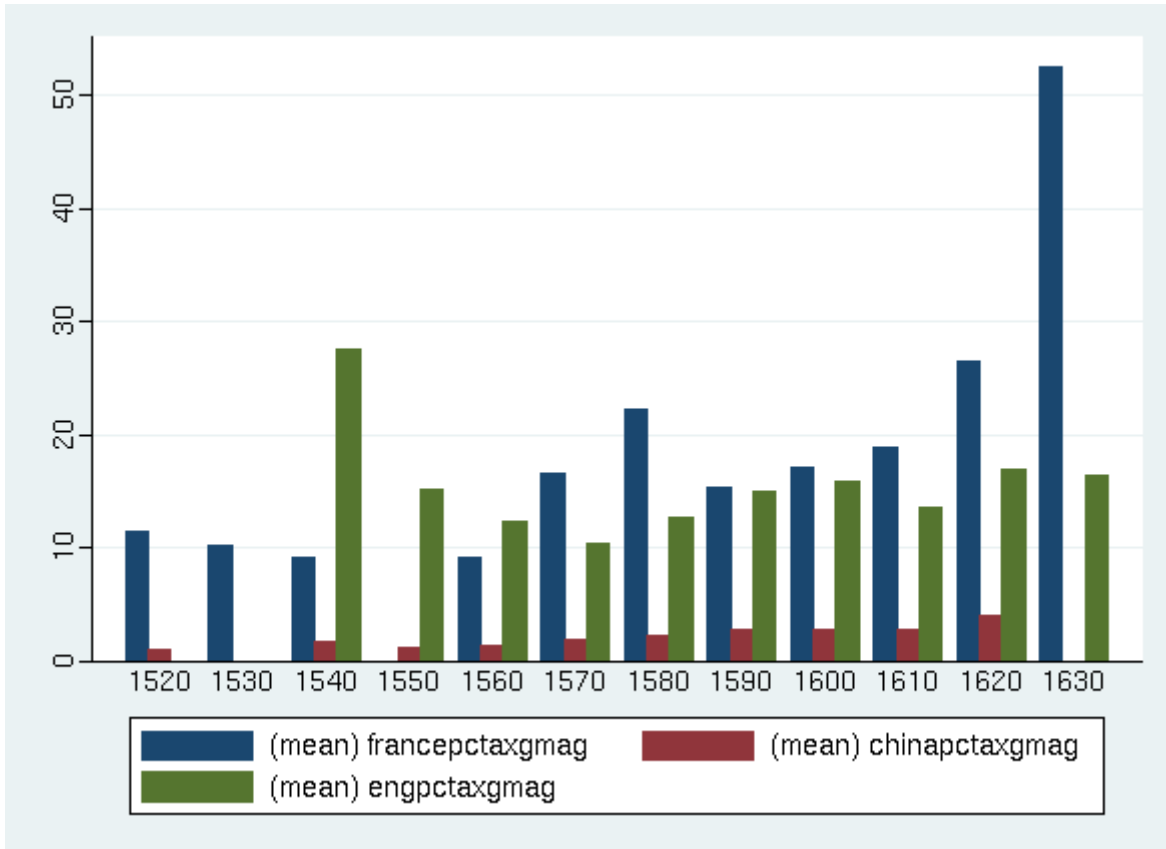


Figure 3: Warning of the danger that a cannon might explode, from an early fifteenth-century cannon maker's manuscript book. Source: (Leng 2002, plate 4)



Figure 4: The central government's per capita tax receipts in China, England, and France in grams of silver: Decennial averages, 1520-1630



Source: Data collected for a comparison of Europe and China by Margaret Chen and the author.

Note: In the legend, China is represented by the bars labeled chinapctaxmag, France by francepctaxmag, and England by engpctaxmag.

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¹ For the divergence debate, see Wong 1997; Pomeranz 2000; van Zanden 2003; Goldstone forthcoming Allen 2005; Broadberry and Gupta 2005. For arguments in favor of institutions, see North and Thomas 1973; North and Weingast 1989; Acemoglu, Johnson and Robinson 2002. For the other explanations, see Cosandey 1997; Jacob 1997; Mokyr 2002; Clark 2003; Clark 2007.

² Parker 1996, 5.

³ Diamond 1997. There was of course more to the story of European conquest than disease and technology, even if technology is defined broadly so that it includes logistics, finance, and mobilization of resources. Luck and rivalries among people and powers outside Europe also had an enormous role to play.

⁴ Mallett and Hale 1984, 400.

⁵ See Parry 1970; Inalcik 1975; Parker 1996, 87-89, 126-129, 173-175; Heywood 2002a; Heywood 2002b; Chase 2003, 2, 97-98; and Agoston 2005, especially pp. 10-12 (the source of the quotation about the ordnance industry), and 193-94. Agoston demonstrates that the Ottomans produced most of their own weapons in the early modern period, but he acknowledges that they did import arms and expertise from Europe. Chase considers the Ottomans a military threat to Europe until the late seventeenth century, and he quotes a 1644 Chinese opinion that Ottoman guns were better than European ones. But he also acknowledges that the Ottomans were not at the frontier of military technology and that they often depended on Christian “renegades” for help. As Parry points out, the western Europeans shipped weapons to the Ottomans despite a papal ban on military trade with the Muslims.

⁶ Wong 1997, 89-90; Pomeranz 2000, 199-200.

⁷ Guilmartin 1974, 255-263; Agoston 2005

⁸ With volley fire, infantrymen were trained to line up in long rows. The first row would fire their muskets, and while they were reloading, the rows behind them would advance to the front and take their place on the firing line. For volley fire in Europe and Japan, see Parker 1996, 18-19, 140-141.

⁹ Agoston, 10-12, 193-94, argues that the European technological superiority was minimal, at least until the late seventeenth century, but he does admit that it was “European military experts who sold their expertise to the Ottomans and not vice versa.”

¹⁰ Kennedy 1987, 16-24

¹¹ For quantitative evidence for the productivity growth in early modern Europe’s military sector, see Hoffman 2006. See also Carlo Cipolla’s pioneering study Cipolla 1965.

¹² Hoffman 1996; Clark 2007

¹³ For money spent on the military, see Hoffman and Rosenthal 1997, Table III.1.

¹⁴ Harding 1991, 28-30; Lynn 2000. As Harding shows, public opinion could affect decisions to go to war, but it could in turn be influenced by propaganda. For decisions about war in Renaissance Italy, see Mallett 1974, 88.

¹⁵ Louis-XIV and Sonnino 1970, 124; Machiavelli 1977, 247; Hale 1985, 29-32; Cornette 1993, 16-19, 23-64, 151-176.

¹⁶ Lynn 2000; Bell 2007, 29-35.

¹⁷ Civil wars are of course another matter; in Table 2 they include all hostilities that involve domestic enemies, even if foreign powers were also engaged. Table 2 also

demonstrates that in the years 1500-1799 simply participating in a foreign war was never so unpopular that it toppled monarchs, at least in the great powers of western Europe.

¹⁸ Hoffman and Norberg 1994; Hoffman and Rosenthal 1997; Hoffman and Rosenthal 2002

¹⁹ See Fullerton and McAfee 1999 and www.darpa.mil.

²⁰ The model here comes from Fullerton and McAfee 1999. In their model, firms have to pay an entry fee to enter a research tournament. If they do enter, they also exert effort trying to innovate, with the cost of the effort varying from firm to firm. Greater total effort raises the odds of innovation, and it is easy to construct examples in which the addition of a third firm cuts total effort. The cost of designing such a tournament is the value of the prize less the entry fees that are collected. Applying this model to early modern Europe does assume that dynastic considerations do not turn the tournament into a repeated game. Since foreign policy varied greatly from ruler to ruler and within dynasties, the assumption does not seem unreasonable.

²¹ Parker 1996; Landers 2003

²² Guilmartin, Gallies, p. XXX; Corvisier 1997, 1: 490, 497-500. As Corvisier shows France lacked good ports, particularly ones deep enough for ships of the line, which could draw 7.5 meters of water.

²³ Guilmartin 1974, 262-263; Pepper and Adams 1986; Parker 1996; Corvisier 1997, 1: 449-484. Many of the best early modern military architects were Italian; their services were sought throughout Europe and in the Americas and Asia: Pepper and Adams 1986; Goodman 1988, 126-129.

²⁴ For Great Britain, the estimates come from Kennedy 1987 Table 2. They reach 27

percent during the Seven Years War and 28 percent during the wars of the French Revolution and Napoleon. For France, I assume that taxes are 12 percent of GDP and allow military expenditure to range from 45 to 85 percent of tax revenues. The 12 percent figure is derived from Mathias and O'Brien 1976, Table 5.

²⁵ Brzoska 1995, Table 3. Israel was allocating 8 percent of its GDP to the military.

²⁶ Hoffman and Norberg 1994; Epstein 2000; Hoffman and Rosenthal 2002; Dincecco 2009

²⁷ Traite pour l'etablissement de deux hauts fourneaux pres Montcenis 1782; Goodman 1988, 123-141; Chaloner, Farnie and Henderson 1989, 19-32. The British technology including a cannon foundry with a boring mill and blast furnaces that smelted iron with coke. See also Cipolla 1965 on English efforts to encourage the manufacture of cast iron cannons.

²⁸ In the seventeenth century, for instance, the Dutch navy copied England's successful tactics, and French kept a close eye on the design of English ships: Armements 1691-1759; Bruijn 1993, 88-89

²⁹ Mallett 1974; Hale 1985, 69, 141-146; Parker 1996, 50-52; Hanlon 1998; Bell 2007, 28. For an earlier example of how the technology of making weapons spread, see Cipolla 1965 for the role that the Dutch played in establishing the armaments industry in Sweden.

³⁰ Willers 1973, 220-308; Cornette 1993, 47-48; Parker 1996, 19-24

³¹ The argument here depends on the assumption that the European tournament was not a repeated game and that efforts to improve technology behave like independent draws from a common distribution. Technically, the second assumption amounts to saying that distribution of each competitor's innovations x is $F^z(x)$ where z is the competitor's effort

and F is a distribution common to all competitors. See Fullerton and McAfee 1999 for details.

³² Guilmartin 1974, 253-254; Guilmartin 1983; Glete 1993, 58-61

³³ Benjamin and Tifrea 2007, 981-984. As the authors argue, the lower death rates were not simply the result of Britain's naval dominance in the late eighteenth century, for they were already lower by 1710, before Britain's dominance was overwhelming. The calculations are based on a hazard rate fractional logit regression and assume that the intensity and frequency of battle are held constant.

³⁴ For evidence and the economics of the argument, see Hoffman 2006

³⁵ The implied rate of total factor productivity growth is 3.0 percent per year, which is impressive by modern standards. See Hoffman 2006 for details.

³⁶ Here I draw upon Parker 1996, 140-143; Chase 2003, 175-196, and upon forthcoming work by Thomas Conlan.

³⁷ For China, see Chase 2003, 1-27, 35-41, 141-171. A similar for India can be found in Gommans 2003.

³⁸ Chase 2003, 151-154. Private ownership and production of guns was by and large not restricted in Europe.

³⁹ Here I am relying on ongoing research by Li Bozhong.

⁴⁰ The quotation here is from Chase 2003, 30. The early Qing dynasty was quite different: Perdue 2005.

⁴¹ Elia and Ricci 1942, 1: 66. Ricci's remarks cannot simply be dismissed as the sort of stereotyping that was common among westerners in China, because as this and other passages make clear, he admired the emperors' avoidance of war.

⁴² Spence 1969, 15, 29; Chase 2003, 167-171, and Li Bozhong, personal communication.

The issue was not the ability to cast metal, for Chinese craftsmen were likely as good or better than Europeans at doing that. Rather, it was the design and testing of the cannons.

⁴³ In Fullerton and McAfee's model, the lowest cost competitors enter the tournament. If their innovation is readily available at a competitive price, then a competitor in a second tournament may find it more advantageous simply to buy it from the competitors in the first tournament and avoid the effort and fixed costs of seeking innovations on his own. This argument does assume that competitors outside Europe have to duplicate the Europeans' efforts and pay the same fixed costs, which is not unreasonable.

⁴⁴ Margaret Chen, a graduate student in economics at UC Davis, has gathered data on Chinese military inventions over the past three millennia for a comparative paper on Europe and China that she and I are doing. Other things being equal, the military inventions were more common under dynasties that spent more than half their time at war.

⁴⁵ The argument about the Ottomans and nomads is taken from Chase, and the evidence about tax receipts (measured relative to GDP) comes from research Sevket Pamuk and I have done on a comparison of the Ottoman Empire and France in the sixteenth and eighteenth centuries. The differences in warfare also mattered at sea. In a forthcoming book, Daniel Headrick notes that the speed and maneuverability of Ottoman galleys kept the Portuguese from dominating the Red Sea. The story was different out on the ocean.

⁴⁶ Parry 1970; Agoston 2005, 10-12, 193-194

⁴⁷ Kolff 1990; Gommans and Kolff 2001; Gommans 2003.

⁴⁸ Even defenders of Indian military prowess admit that the advances with the gun

powder technology by and large came from the West. See Subrahmanyam 1987; Barua 1994; Alavi 1995, 24-25; Cooper 2003, 31-32, 42-44, 289-294.

⁴⁹ Kolff 1990; Gommans and Kolff 2001; Gommans 2003.

⁵⁰ Gommans 2003. The reasons why alliances were weak are complex. As Gommans points out, it was difficult for Indian warriors to cement alliances via marriage, something that was quite common in Europe. It may also have been easier to defect from an alliance and hire soldiers, because wars were fought during the agricultural slack season when wages were low. In Europe, by contrast, the off season—winter—was a time for armies to rest. It is worth pointing out that alliances in eighteenth-century Europe were less stable than they had been a century or two earlier, which could have undermined effort by European states. But European states seem not to have faced such high political and economic costs of centralizing taxation, and those costs, as we will see, would reduce overall effort and productivity growth in the military sector.

⁵¹ Gommans and Kolff 2001; Gommans 2003

⁵² Studer 2008

⁵³ In McAfee and Ferguson's model, if the costs of exerting effort are all multiplied by a factor $g > 1$, then the number of competitors in the tournament remains the same, but total effort drops.

⁵⁴ Alavi 1995; Gommans and Kolff 2001; Cooper 2003; Gommans 2003. The East India Company would of course still have to content with fragmented grain markets.

⁵⁵ Hale 1985, 91-140; Cornette 1993, 294; Hanlon 1998, 241-267; Drevillon 2005; Bell 2007, 5-48

⁵⁶ Fullerton and McAfee 1999. To design an efficient tournament when the competitors'

costs are unknown, Fullerton and McAfee suggest holding an initial auction for the rights to enter a tournament; the designer then selects the two highest bidders in this auction to compete in the tournament. The initial action would have a nominal prize, and all competitors would have to pay what they bid whether or not they were subsequently selected for the tournament. Raising a standing army resembles paying a bid in an initial auction where the prize is prestige or reputation. War between the rulers with the two biggest armies would then be the tournament.